S103 Discovering science

Assessment Booklet 2 (February 2007 presentation)

The Open University

Contents

IMPORTANT INFORMATION ABOUT TMAS 06–09

You will need to select THREE TMAs from TMAs 06, 07, 08 and 09. If you submit all four, the last one you submit will be returned to you unmarked. TMAs 07, 08 and 09 form part of Assessment Booklet 3, which you will receive in your third mailing of course materials. TMA 06 is included in this Assessment Booklet (Assessment Booklet 2). We STRONGLY recommend that you submit TMA 06 as one of your three choices. The material that it assesses underpins, to a greater or lesser extent, concepts that you will need to rely on at higher levels of study.

This Assessment Booklet is for students who are studying the S103 2007 presentation, which began in February 2007.

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Learning outcomes for S103

Each of the questions in these TMAs indicates which of the learning outcomes for the course (listed below, reprinted from the Appendix in the *Course Guide*) are being assessed.

Knowledge and understanding

In the context of the topics covered in S103, you should be able to demonstrate knowledge and understanding of:

1 the terminology, nomenclature, classification systems, conventions and units used in biology, chemistry, Earth sciences and physics, appropriate to study at this level;

2 some of the underlying facts, concepts, principles and theories associated with the study of science;

3 methods of acquiring, interpreting and analysing scientific information;

4 the processes that shape the natural world at different time-scales and scales of size;

5 the benefits of a multidisciplinary and interdisciplinary approach in advancing scientific knowledge and understanding;

6 the contribution of science to informed debate about some aspects of environmental and social issues.

Cognitive skills

On completion of S103, you should also be able to:

1 make sense of information presented in a variety of ways, including text, tables, graphs, diagrams and figures, numerical and mathematical descriptions, and computer-based multimedia;

2 understand and make use of the facts, concepts, principles and theories relating to the main subject areas in science;

3 apply your knowledge and understanding of scientific concepts to address familiar and unfamiliar problems;

4 describe, analyse and interpret scientific information and data;

5 make links/connections and recognise associations/relationships among different subject areas;

6 understand the use of simple analogies and models in order to explain scientific concepts;

7 classify an appropriate range of organisms, objects and/or systems on the basis of similarities and differences.

Key skills

On completion of S103, you should also be able to:

1 communicate scientific topics clearly and concisely, using methods appropriate to your purpose and audience;

2 use mathematical skills appropriate to the study of science at this level;

3 solve numerical problems using non-computer based methods;

4 process, interpret and present data using appropriate qualitative and quantitative techniques;

5 plan and implement efficiently, effective ways of working, so demonstrating time-management and organizational skills;

6 reflect on the experience of learning in order to develop more effective learning strategies.

Practical and/or professional skills

On completion of S103, you should also be able to:

1 handle materials safely by complying with safety instructions and being aware of any specific hazards associated with the use of the materials;

2 make and record appropriately, observations and measurements of a quantitative and qualitative nature;

3 consider issues of accuracy, precision and uncertainty in the recording and analysing of data;

4 interpret data derived from laboratory and field observations and measurements in terms of the appropriate underlying scientific theories.

Tutor Marked Assignment S103 04

Covering: Blocks 4 and 5

Cut-off date: Tuesday 8 May 2007

Completing your TMA

Use A4-sized paper for your assignment, and leave a wide margin for your tutor's comments. Put your name, personal identifier, the course code and the assignment number at the top of *every* sheet.

Sending in your TMA

You must attach the TMA form (PT3), enclosed with the course materials, to your assignment when you send it to your tutor. You should complete Section 1 of the form, taking particular care to enter correctly your personal identifier, the course code and the TMA number, as described in 'Submitting TMAs' in the *Assessment Handbook*. Before mailing, make sure that you have put your name and address on the envelope. Do *not* send the TMA to your tutor using recorded or guaranteed delivery. *Do* make sure that you obtain a proof of posting certificate and, if possible, that you have kept a copy of your TMA.

Introduction

This assignment consists of two questions that relate to Block 4 and two questions that relate to Block 5.

You must submit *all* of your answers to the TMA at the same time, along with the PT3 form.

Each question in this TMA indicates which of the block objectives (listed in the Study Files for Blocks 4 and 5) are being tested and what percentage of the marks for the assignment are allocated to it.

You are advised to read Question 2 of this assignment before you study Section 7 of Block 4, particularly the DVD-multimedia activity 'Ecological chains: finding the links'. The question requires you to write a short account, so when answering it, remember that you *must not* simply copy or closely paraphrase chunks of text from the course materials but *must* write in your own words. If you are found to have plagiarized material from the course or elsewhere, marks may be deducted from your score.

You should bear in mind the detailed advice on how to tackle the S103 assignments given in 'General advice about S103 assignments', in *Assessment Booklet 1*; you may wish to read the advice again before doing this assignment. *You may be penalized for not paying attention to this advice, particularly in relation to presenting answers to calculations and including diagrams*. You are also advised to take account of any advice given by your tutor on TMAs 02 and 03.

If you had any problems in tackling TMA 03, you may find it useful to re-read *The Sciences Good Study Guide* (SGSG) Chapter 9, Section 6, pp. 259–64, before starting work on TMA 04.

Question 1

This question relates mainly to Objectives 19, 20, 23 and 28 of Block 4, and carries 30% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–3

Cognitive skills: outcomes 1, 2 and 4

Key skills: outcomes 1, 2 and 4

The pin oak (*Quercus palustris*) has fruits known as acorns. The size of an acorn is variable, with some being more than twice the size of others. Previous research has shown that larger acorns have a considerably higher success rate in terms of producing successful seedlings. This is believed to be a result of the larger acorn storing more food, which supplies the seedling with more materials and energy that help it to grow and push its way up through dead leaves on the woodland floor to reach sunlight.

The acorns of the pin oak are smaller than the acorns of many other species of oak around the world. An American researcher investigated why this should be so, since one might have expected natural selection to have favoured individuals with large acorns. The following method was used in the investigation.

Acorns falling from trees were collected by placing large baskets (each with a collecting area of 0.4 m^2) on the woodland floor. The acorns that fell in were regularly removed and weighed. Twelve baskets were used (labelled A–L) and each was placed under the canopy of a separate, randomly selected pin oak tree (the trees were also labelled A–L to correspond with the basket labels). The results are shown in Table 1 below.

Table 1 The number and mean mass of acorns collected.

Basket	Number of acorns collected		Mean acorn dry mass /g mass	
A	64	23.7	0.37	B B
B	38	23.6	0.62	C
C	47	28.2	0.60	B
D	15	21.9	1.46	E
E	18	28.3	1.57	F
F	71	28.4	0.40	B
G	55	28.1	0.51	B
H	22	26.0	1.09	D
I	28	28.3	1.01	D
J	38	30.0	0.79	C
K	29	22.6	0.78	C
L	40	27.2	0.68	C

0.30 = A
0.30 - 0.60 = B
0.60 - 0.90 = C
0.90 - 1.20 = D
1.20 - 1.50 = E
1.50 - 1.80 = F
1.80 - 2.10 = G

B = 4
C = 4
D = 2
E = 1
F = 1

A C

(a) (*4 marks*) Plot by hand, on the graph paper provided for this question on page 25 of this booklet, a *histogram* to show the distribution of mean acorn mass between trees. **Hint**: use mass class intervals of 0.30 g in the range 0.00 g to 2.10 g and plot the number of trees belonging to each interval.

(b) (*3 marks*) Plot by hand on the graph paper provided on page 27 of this booklet, a *graph* to relate the mean mass of acorns for each tree to the number of acorns in the basket. **Hint:** plot the number of acorns in a basket along the *x*-axis.

(c) (*2 marks*) Briefly describe the pattern of the points on your graph from part (b), identifying any trend you can see.

(d) (*4 marks*) Now calculate both the yield of acorns per square metre under each tree (i.e. the total dry mass of acorns per unit area, noting that the baskets were each 0.4 m^2 in area) *and* the number of acorns per square metre under each tree. Express your results to one decimal place and present them as a table. Then plot your results on a *graph*, using the paper provided on page 29 of this booklet, showing yield against number of acorns collected per square metre.

(e) (*4 marks*) Compare your two graphs from parts (b) and (d). Can you identify a trade-off relating to acorn mass? If so, describe what you think that trade-off might be.

The researcher decided to assess acorns from trees A, E and J to compare their ability to become established as seedlings. She collected 100 acorns from each tree, then placed them in marked positions on the woodland floor. Eighteen months later she returned to record which acorns had germinated and produced a surviving seedling. She found 7 seedlings from tree A acorns, 18 seedlings from tree E acorns, and 14 seedlings from tree J acorns.

(f) (*3 marks*) Using these observed survival values, calculate how many seedlings you would expect to result from the acorns falling on a one square-metre area beneath each of these three trees. Please show your working.

(g) (*4 marks*) Is your answer to part (f) consistent with a hypothesis that natural selection favours acorns of a mass which maximises the number of offspring? **Hint**: you may wish to look at where trees A, E and J fell on your histogram.

Previous studies have shown that pin oaks do not produce similar yields every year. A particular observation is that when a tree produces a yield greater than 100 g m^{-2}, they produced few, if any acorns the following year.

(h) (*2 marks*) Suggest a reason for this observation.

(i) (*2 marks*) What implications does such an observation have for your answer to part (f)?

(j) (*2 marks*) Identify two other factors not accounted for in the study described here that may influence the relationship between mean acorn mass and the fitness of a tree. Briefly state how each factor may affect the trade off.

Do not forget to send your completed graphs to your tutor with your TMA.

A = 0.37

E = 1.57

J = 0.79

Question 2

This question relates mainly to Block 4 Objective 15, and carries 20% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1 and 2

Cognitive skills: outcomes 1 and 2

Key skills: outcome 1

The terms ***r*-strategy** and ***K*-strategy** are used to describe reproductive strategies that species adopt as a result of inhabiting a given environment. *Write* a short account of *not more than 350 words* where you outline the differences in reproductive strategies shown by species that are predominantly *r*-strategists and species that are predominantly *K*-strategists. In your account you should *explain* why each particular strategy is beneficial to these species.

When writing your account:

- You should write at a level appropriate to students studying S103 (you can assume they have completed the study of Blocks 1–3 of the course).
- You should state the number of words used at the end of your account.
- You do *not* need to write a formal introduction or a conclusion for this short piece of writing.
- It is essential that you *use your own words*. Using sentences/paragraphs directly from the course material is not permitted and you **may lose marks** if you do this. You may find it useful to revisit Block 1 Activities 5.8 and 6.1 to remind you how to extract key points from the text and then turn those points into a short account. In addition you should re-read your tutor's comments from TMA 02.

Of the 20 marks available for this question 14 will be awarded for the scientific content of your account, including your use of diagrams. The remaining 6 marks will be awarded for communication skills (conciseness, coherence and clarity).

Sexual maturity
opportunity to reproduce
large brood
Small progeny
high individual mortality rate
r-s reproduce only once or twice in their lifetime

Stable environments
live comparatively long
Sexual maturity later age
Small number of progeny
give enough resource to each one to grow

Question 3

This question relates mainly to Objectives 4, 5, 13, 15, 17, 19 and 20 of Block 5, and carries 20% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–3

Cognitive skills: outcomes 2–4

Key skills: outcomes 2 and 3

In all calculations, do not only write down your answer as a number. *Explain* what you are doing and what symbols you are using, and remember to state any equations you are using.

(a) (*5 marks*) A car and its driver have a total mass of 1.2×10^3 kg. The car, initially at rest, accelerates along a flat road such that after 8.5 s it has a speed of 16 m s^{-1}. *Calculate* the kinetic energy of the car after 8.5 s. (Your final answer should be in scientific notation using an appropriate number of significant figures and appropriate units.)

(b) (*5 marks*) *Calculate* the average power developed over the 8.5 s that the car was accelerating. (Your final answer should be in scientific notation using an appropriate number of significant figures and appropriate units.)

(c) (*5 marks*) The car sets off from a starting point. It is then driven to a final point that is 95 m higher than the starting point. *Calculate* the increase in gravitational potential energy that the car has obtained in moving from its starting point to its final point. (Your final answer should be in scientific notation using an appropriate number of significant figures and appropriate units.)

(d) (*3 marks*) Suppose that, having set off from the same starting point as in part (c), the driver takes an alternative route to the same final point. This route involves driving to an intermediate point that is 130 m higher than the starting point, before carrying on to the same final point as before (i.e. 95 m higher than the starting point). For this alternative route, *determine* the overall change in gravitational potential energy that the car undergoes in moving from its starting point to the final point. Justify your answer.

(e) (*2 marks*) If you were to take account of friction in the car's engine and transmission, and air resistance, how would this change the values for the increase in gravitational potential energy that you calculated in parts (c) and (d)? You don't need to recalculate these values but comment on how they would change (i.e. increase, decrease, or stay the same).

Question 4

You should not attempt this question until you have completed Activity 6.1 in the Study File for Block 5. If you used a hob-top kettle, instead of an electric kettle, you should answer the alternative Question 4, on page 9

This question relates mainly to Objectives 11–15 and 20 of Block 5, and carries 30% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–3

Cognitive skills: outcomes 1, 2, and 4

Key skills: outcomes 1–4

Practical and/or professional skills: 1–4

If you have a disability that prevents you from carrying out the experiment for yourself you should contact your tutor for advice.

In Activity 6.1 (pp. 8–11 in the Study File for Block 5) you carried out an experiment to measure the specific heat of water. In this question we want to know how you carried out the experiment, the results you obtained, and some of the uncertainties that arose in your measurements.

In Activity 6.2 (pp. 12–13 in the Study File for Block 5) you were shown how to write an account of a different experiment that measured the latent heat of vaporization of water.

(a) (*10 marks*) Write a description of the method that you used to measure the specific heat of water. You should look at the example of writing an experimental method that is given on p. 13 of the Study File and follow the guidance given in the comments column. Also look at the table on p.11 of the Study File. (You do not need to include a diagram or an abstract.) Your description should be sufficiently detailed for someone else to carry out the experiment using exactly the same equipment and procedures that you used.

(b) (*8 marks*) Construct a table to show the results of your experiment following the example given on p. 11 of the Study File. Adapt this example table to suit the method you used for your experiment and the measurements you recorded. You should also include a third column in which you *estimate the uncertainties* in your measurements (where appropriate) and comment on *how you have estimated them*.

(c) (*6 marks*) Assuming *all* the delivered electrical energy is used to heat the water, calculate a value for the specific heat of water based on the results of your experiment. Show all the stages in your working and express your answer to an appropriate number of significant figures.

Note: on some electric kettles, no *exact* power rating is given. If, for example, the kettle's power is given as 2800–3000 W, use the *average* value of 2900 W in your calculations.

(d) (*6 marks*) In Box 2.1 of Block 2 (pp. 13–14) you learned about random and systematic uncertainties in measurements. In your experiment there will have been several main sources of potential uncertainties including: measuring the mass of water, measuring the initial and final water temperatures and measuring the time interval.

Copy out Table 2 below and complete it by:

(i) describing *one* example of how each source of uncertainty might have occurred in your experiment

(ii) stating whether the uncertainty is random or systematic (or both).
Hint: consider how the values of the quantities you measured might vary if you were to repeat the experiment several times.

Table 2 Uncertainties in the results of an experiment to measure the specific heat of water.

Source of uncertainty	**How uncertainty may have occurred (one example)**	**Systematic or random?**
Mass of water		
Initial temperature		
Final temperature		
Time interval		

Alternative Question 4

You should answer this question if you used a hob-top kettle, instead of an electric kettle. You should not attempt this question until you have completed Activity 6.1 in the Study File for Block 5.

This question relates mainly to Objectives 11–15 and 20 of Block 5, and carries 30% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–3

Cognitive skills: outcomes 1, 2, and 4

Key skills: outcomes 1–4

Practical and/or professional skills: 1–4

If you have a disability that prevents you from carrying out the experiment for yourself you should contact your tutor for advice.

In Activity 6.1 (pp. 8–11 in the Study File for Block 5) you were asked to carry out an experiment to measure the specific heat of water. In this question we want you to carry out an identical experiment, except that you will assume a value for the specific heat of water and then use your results to work out the energy supplied to the water and the power equivalence.

The energy supplied, q, can be derived by rearranging the equation $c = q/m\Delta T$ to make q the subject:

$$q = c \times m\Delta T$$

You should use the accepted value of c (specific heat of water) as 4.2×10^3 J kg^{-1} °C^{-1}. You can then calculate the value of power, P, by rearranging the equation $E = P \times t$ to make P the subject:

$$P = \frac{E}{t}$$

We want to know how you carried out this experiment, the results you obtained, and some of the uncertainties that arose in your measurements.

In Activity 6.2 (pp. 12–13 in the Study File for Block 5) you were shown how to write an account of a different experiment that measured the latent heat of vaporization of water.

(a) (*10 marks*) Write a description of the method you used to measure the power equivalence and the energy used to boil a kettle of water. You should look at the example of writing an experimental method that is given on p. 13 of the Study File and follow the guidance given in the comments column. Also look at the table on page 11 of the Study File. (You do not need to include a diagram or an abstract.) Your description should be sufficiently detailed for someone else to carry out the experiment using exactly the same equipment and procedures that you used.

(b) (*8 marks*) Construct a table to show the results of your experiment following the example given on p. 11 of the Study File. Adapt this example table to suit the method you used for your experiment and the measurements you recorded. You should also include a third column in which you *estimate the uncertainties* in your measurements (where appropriate) and comment on *how you have estimated them.*

(c) (*6 marks*) Assuming *all* the delivered energy is used to heat the water, *calculate* values for the power equivalence and the energy used to boil the water, based on the results of your experiment. Show all the stages in your working and express your answer to an appropriate number of significant figures.

(d) (*6 marks*) In Box 2.1 of Block 2 (pp 13–14) you learned about random and systematic uncertainties in measurements. In your experiment there will have been several main sources of potential uncertainties: measuring the mass of water, measuring the initial and final temperatures and measuring the time interval.

Copy out Table 2 on page 9 and complete it by:

(i) describing *one* example of how each source of uncertainty might have occurred in your experiment

(ii) stating whether the uncertainty is random or systematic (or both).
Hint: consider how the values of the quantities you measured might vary if you were to repeat the experiment several times.

Tutor Marked Assignment S103 05

Covering: Block 6

Cut-off date: Tuesday 29 May 2007

Completing your TMA

Use A4-sized paper for your assignment, and leave a wide margin for your tutor's comments. Put your name, personal identifier, the course code and the assignment number at the top of *every* sheet.

Sending in your TMA

You must attach the TMA form (PT3), enclosed with the course materials, to your assignment when you send it to your tutor. You should complete Section 1 of the form, taking particular care to enter correctly your personal identifier, the course code and the TMA number, as described in 'Submitting TMAs' in the *Assessment Handbook*. Before mailing, make sure that you have put your name and address on the envelope. Do *not* send the TMA to your tutor using recorded or guaranteed delivery. *Do* make sure that you obtain a proof of posting certificate and, if possible, that you have kept a copy of your TMA.

Introduction

This assignment consists of four questions that relate to Block 6.

You must submit *all* of your answers to the TMA at the same time, along with the PT3 form.

Each question indicates which of the block objectives (listed in the *Study File for Block 6*) are being tested and what percentage of the marks for the assignment are allocated to it.

You should bear in mind the detailed advice on how to tackle S103 assignments given in 'General advice about S103 assignments' in *Assessment Booklet 1*; you may wish to read the advice again before doing this assignment. *You may be penalized for not paying attention to this advice, particularly in relation to presenting answers to calculations and including diagrams.* You *must* ensure that you use your own words and do not copy out whole sentences from the books, or you will lose marks. You are also advised to take account of any advice given by your tutor on previous TMAs.

Question 1

This question relates mainly to Objectives 1, 4, 7, 8, 13, and 24 of Block 6, and carries 24% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–4

Cognitive skills: outcomes 1–3

Key skills: outcomes 1–3

Carbides of some metals will react with water to produce gases, such as methane, that contain only the elements carbon and hydrogen. The solid carbides are easier to transport than the gases, and can be used to generate the gas when and where it is needed. In the early twentieth century, car headlamps were manufactured so that light was produced by burning the gas formed when water reacted with calcium carbide. Lights based on the same principle are used today by 'cavers'.

(a) (*13 marks*) This part of the question concerns the properties of beryllium carbide.

(i) From the name of the compound, *state* which elements are contained in beryllium carbide.

(ii) Beryllium hydride has the formula BeH_2. *State* the valency of both beryllium in its hydride, and of carbon in its hydride (methane).

(iii) Assuming that both beryllium and carbon have the same valency as in their hydrides, predict the empirical formula for beryllium carbide. *Explain briefly* how you determined the formula.

(iv) Beryllium carbide reacts with water to produce methane and solid beryllium hydroxide, $Be(OH)_2$. *Write* a *balanced* chemical equation for the reaction of beryllium carbide with water (remember to include the physical states of reactants and products). *Explain briefly* why your equation is balanced.

(v) Beryllium carbide powder is labelled 'dangerous when wet'. Why is this?

(b) (*11 marks*) This question concerns a scenario where a chemist decides to fill a balloon with methane.

When writing your answers, remember to show the successive steps in the calculations, and to explain your reasoning. You should also quote your answer to each part of the question to an appropriate number of significant figures, though you may sometimes wish to carry more figures over to subsequent calculations.

The chemist fills the balloon with methane outside, on a day when the air temperature is 0 °C and the pressure is 760 mmHg.

(i) The balloon is filled with 3.2 g of methane, reaching a pressure of 950 mmHg inside the balloon. At standard temperature and pressure (STP) 3.2 g of methane occupies a volume of 4 480 cm^3. *Calculate* the volume of methane in the balloon, assuming that the temperature inside the balloon is 0.0 °C, and hence obtain the density of the methane in the balloon.

(ii) The chemist ties off the balloon, holds it out at arm's length and then lets go of it. Will the balloon rise up in the air or sink towards the ground? Describe briefly (*in one or two short sentences*) how you arrived at your conclusion. You can ignore the weight of the balloon itself; the density of air at STP is 1.29 g $litre^{-1}$.

(iii) If, on a warm Summer's day, the balloon was filled to the limit of its elasticity with the same mass of methane and to the same volume, what effect would this have on the density of methane within the balloon?

Question 2

This question relates mainly to Objectives 1, 4, 5, 7–9, 11 12, 24, 25, 28, and 29 of Block 6, and carries 35% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–3

Cognitive skills: outcomes 1–3

Key skills: outcomes 1–3

When arsenic oxide (As_4O_6) is heated with sulfur a red or orange solid 'arsenic sulfide' is formed. This is one of the more unusual materials used in fireworks, as it violently inflames when heated with potassium nitrate. The compound has also been of interest to chemists because there is a change in its molar mass when it is heated. In this question, you are asked to determine its empirical formula and its molecular formulae at two different temperatures.

When writing your answers, remember to show the successive steps in the calculations, and to explain your reasoning. You should also quote your answer to each part of the question to an appropriate number of significant figures, though you may sometimes wish to carry more figures over to subsequent calculations.

(a) (*13 marks*) When the composition of the red or orange solid is determined it is found to contain 70.0% arsenic by mass; the remainder being comprised of sulfur. Use the percentage composition of arsenic and sulfur to obtain the empirical formula of the compound.

(b) When the compound is heated above 565 °C it becomes a gas. Table 1 below lists the volumes of gas produced at two different temperatures at standard pressure (760 mmHg).

Table 1 Volume of gas generated at two temperatures from a sample mass of arsenic sulfide.

Sample mass/g	Temperature/°C	Pressure/mmHg	Volume/cm^3
0.345	650 (3 sig figs)	760 (3 sig figs)	60.5
0.345	1573	760 (3 sig figs)	242.0

(i) (*6 marks*) Using the information for 650 °C, *calculate* the volume that the sample would have at 0 °C and standard pressure, assuming that it remained gaseous.

(ii) (*2 marks*) *Calculate* the density, in g $litre^{-1}$, of this gaseous 'arsenic sulfide' at 0.00 °C and 760 mmHg (3 sig figs).

(iii) (*8 marks*) *Calculate* the molecular formula of the 'arsenic sulfide' when it is in the gaseous state at 650 °C (3 sig figs). Show your reasoning.

(iv) (*6 marks*) *State* the molecular formula at 1573 °C, and explain, *in one or two short sentences,* how you came to this conclusion.

Question 3

This question relates mainly to Objectives 1, 11 and 12 of Block 6, and carries 14% of the marks for this assignment. It will also help you with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–3

Cognitive skills: outcomes 1–3

Key skills: outcome 1

Chrysoberyl is a semi-precious gemstone, usually green or yellow in colour. It is a source of the element beryllium, and is also known as beryllium di-aluminate, indicating that it contains only beryllium, aluminium and oxygen.

A piece of this material was analysed with the following results:

12.7 g of beryllium di-aluminate contained 0.9 g of beryllium and 5.4 g of aluminium.

(a) (*2 marks*) *Calculate* the mass of oxygen in the sample of beryllium di-aluminate.

(b) (*10 marks*) From your answer to part (a) *calculate* (i) the mass of oxygen, and (ii) the mass of aluminium that combines with *one mole* of beryllium atoms to produce beryllium di-aluminate. How many moles of oxygen atoms and how many moles of aluminium atoms do these masses represent?
Note: use the table of relative atomic masses in Block 6.

(c) (*2 marks*) Use your answer to part (b) to obtain the empirical formula of beryllium di-aluminate, showing your reasoning.

Question 4

This question relates mainly to Objectives 1, 13–18, 21, 22 and 24 of Block 6, and carries 27% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1, 2 and 4

Cognitive skills: outcomes 1–3 and 5

Key skills: outcomes 1 and 3

Of the known chemical elements, those with the highest atomic numbers (above 100) are made through the high-speed collision of the atoms and ions of lighter elements in particle accelerators. Unfortunately, it is hard to detect the formation of new elements because, with such high atomic numbers involved, the atoms that are formed are highly radioactive and very short-lived. However, it has long been believed that somewhere above atomic number 110 there is an 'island of stability' where the atoms of the elements are likely to have longer lifetimes.

This question is concerned with the element which we will refer to as pandemonium, symbol Pn. Observations of nuclei of pandemonium have been reported and each contained 117 protons. Some nuclei contained 175 neutrons and some contained 174 neutrons.

(a) (*3 marks*) *State* the *atomic number* of pandemonium, and give the *full symbol* for the isotope with 175 neutrons.

(b) (*4 marks*)

(i) Give the *Period* and the *Group* of the Periodic Table in which you would expect pandemonium to be found, *explaining* how you arrived at your conclusions. (*One or two sentences*)

(ii) *Name* another chemical element in the Periodic Table that you would expect pandemonium to closely resemble.

(c) (*13 marks*)

(i) *State*, giving your reasoning, whether you would expect pandemonium to be a metal, a semi-metal or a non-metal. (*A single sentence*)

(ii) Give the empirical formulae of the *highest normal hydride* of pandemonium. *Explain* how you arrived at your conclusions. (*One or two sentences*)

(iii) Give the empirical formulae of the *highest normal oxide*. *Explain* how you arrived at your conclusions. (*One or two sentences*)

(iv) Assuming that pandemonium behaves as a typical member of its group in the Periodic Table, *state* the effect an aqueous solution of pandemonium hydride would have on red and blue litmus paper. *Write* a *balanced* equation for the breakdown of the hydride in aqueous solution.

(d) (*7 marks*) Pandemonium undergoes a succession of six α-decays.

(i) Starting from the isotope of pandemonium with 175 neutrons, what isotope would be the final product of these changes? *Show how you have arrived at your answer.*

(ii) Is this final product a lanthanide, an actinide, a transition element or a typical element?

Tutor Marked Assignment S103 06

Covering: Block 7 (Sections 1–6) and Block 8

Cut-off date: Tuesday 10 July 2007

Completing your TMA

Use A4-sized paper for your assignment, and leave a wide margin for your tutor's comments. Put your name, personal identifier, the course code and the assignment number at the top of *every* sheet.

Sending in your TMA

You must attach the TMA form (PT3), enclosed with the course materials, to your assignment when you send it to your tutor. You should complete Section 1 of the form, taking particular care to enter correctly your personal identifier, the course code and the TMA number, as described in 'Submitting TMAs' in the *Assessment Handbook*. Before mailing, make sure that you have put your name and address on the envelope. Do *not* send the TMA to your tutor using recorded or guaranteed delivery. *Do* make sure that you obtain a proof of posting certificate and, if possible, that you have kept a copy of your TMA.

Introduction

This assignment consists of seven questions, two relating to Block 7 (Sections 1–6), four relating to Block 8 and one relating mainly to Block 2.

You *must* submit all your answers to the TMA at the same time, along with the PT3 form.

Each question indicates which of the block objectives (listed in the Study Files for Blocks 7 and 8) are being tested and what percentage of the marks for the assignment are allocated to it.

You should bear in mind the detailed advice on how to tackle S103 assignments given in 'General advice about S103 assignments' in *Assessment Booklet 1*; you may wish to read the advice again before doing this assignment. *You may be penalized for not paying attention to this advice, particularly in relation to presenting answers to calculations and including diagrams*. You *must* ensure that you use your own words and do not copy out whole sentences from the books, or you will lose marks. You are also advised to take account of any advice given by your tutor on previous TMAs.

Question 1

This question relates mainly to Objectives 1, 4, 5, 23 and 24 of Block 7, and carries 12% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–3

Cognitive skills: outcomes 1–3

Key skills: outcomes 1–3

(a) Some of the energy levels of a mercury atom, including the ground state, are shown in Figure 1.

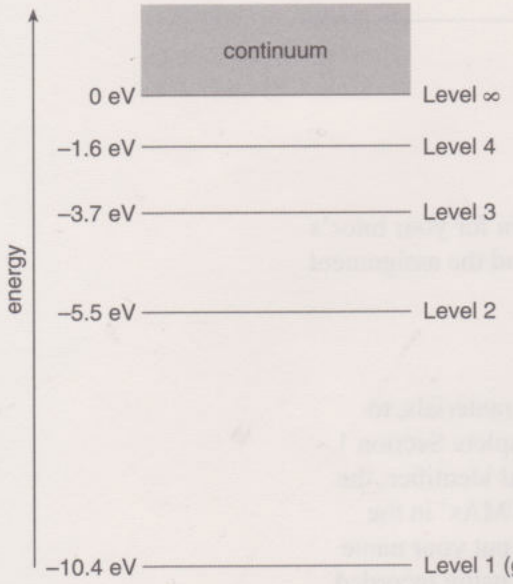


Figure 1 Energy levels of a mercury atom, including ground state.

(i) (*4 marks*) How much energy in electronvolts (eV) is needed to raise an electron from the ground state to *each* of the other four levels shown? Show how you obtained your answers.

(ii) (*1 mark*) What is the ionisation energy of mercury in electronvolts?

(iii) (*3 marks*) A mercury atom is in its ground state. What would happen to a photon of light with an energy of 4.9 eV that was incident on this atom? What would happen if the photon of light incident on the atom had an energy of 8.0 eV?

(b) *(4 marks)* The ground state energy of an unidentified hydrogen-like ion is –217.6 eV. *Calculate* the atomic number of the atom and hence *identify* the element.

Question 2

This question relates mainly to and Objectives 1, 10, 23 and 24 of Block 7 and carries 13% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1–3

Cognitive skills: outcomes 1–3

Key skills: outcomes 1–3

(a) (*5 marks*) $^{238}_{92}\mathrm{U}$ is often known as depleted uranium and is used by the military for enhanced armour plating. $^{238}_{92}\mathrm{U}$ decays by α-decay.

Write the equation for the decay of $^{238}_{92}\mathrm{U}$, showing the thorium isotope produced and any other particles emitted. Thorium subsequently decays by β^- emission. *Write* the equation for this β^- decay, showing the isotope formed and any other particles emitted. Identify the isotope formed.

(b) (*3 marks*) The half-life of another uranium isotope, $^{234}_{92}U$, is 245 000 years. What *percentage* of the original material will be left after 980 000 years?

(c) (*2 marks*) In the emission of an α-particle, the combined masses of the products are less than the mass of the original nucleus. *Explain* what becomes of this 'missing mass'. (*A few sentences*)

(d) (*3 marks*) *Explain* how the idea of mass excess can be used to predict whether a nucleus might be stable or unstable to radioactive decay. (*A few sentences*)

Question 3

This question relates mainly to Objectives 1, 4, 6 and 8 in Block 8, and carries 15% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1 and 2

Cognitive skills: outcomes 2, 3 and 6

Key skills: outcome 1

The radioactive element astatine (symbol At) occurs in the Earth's crust mainly in the form of the isotope $^{210}_{85}At$. Atoms of this isotope have an average half-life of just over 8 hours. Consequently, there is only some 251 g of astatine in the upper kilometre of the Earth's crust, and it has never been possible to study visible amounts of the element and its compounds. However, the methods used on the Block 6 CD-ROM to establish chemical periodicity suggest that astatine will form a compound with sodium, sodium astatide, with the empirical formula NaAt. This question is about the properties of this compound.

(a) (*4 marks*) *State* the *outer* electron configuration of the astatine atom, explaining how you arrived at your conclusion.

(b) (*4 marks*) Using arguments based upon electronegativities, *state* the type of bonding that would be present in sodium astatide. Give your reasons. *(Two or three sentences)*

(c) (*7 marks*) Explain, using electron structures, the way in which the type of bonding present influences the chemical formula of sodium astatide. *(Two or three sentences)*

Question 4

This question relates mainly to Objectives 1, 14 and 19 of Block 8, and carries 10% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1 and 2

Cognitive skills: outcomes 1–3

Key skills: outcomes 1–3

Nitric acid (HNO_3) is a strong acid and the equation for its dissociation in aqueous solution is:

$$HNO_3\,(aq) \rightarrow H^+\,(aq) + NO_3^-(aq)$$

(i) Calculate the hydrogen ion concentration (in mol litre^{-1}) when 0.32 g of nitric acid is dissolved in sufficient water to make 0.050 litres of final solution. Give your answer in scientific notation to an appropriate number of significant figures. Remember to give your reasoning.

(ii) What is the pH of this solution (to the nearest whole number)?

Question 5

This question relates to Objectives 1, 10, 12, 17 and 20 of Block 8, and carries 24% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1, 2 and 4

Cognitive skills: outcomes 1–3

Key skills: outcomes 1–3

The halogens fluorine (F_2) and bromine (Br_2) react together as gases to give the gas bromine pentafluoride, BrF_5. **Note**: ignore the apparently strange valency of this compound.

(a) (*14 marks*) The molar bond enthalpies for fluorine and bromine are as shown below:

Bond	F-F	Br-Br
Molar bond enthalpy/kJ	159	193

The overall enthalpy change (ΔH) for the reaction of five moles of fluorine with one mole of bromine is –429 kJ.

(i) Write down the *balanced* thermochemical equation for this reaction.

(ii) Calculate the mean molar bond enthalpy of the Br-F bonds in bromine pentafluoride. *You should show clearly all the stages in your calculation and explain your reasoning.*

(b) (*10 marks*) The reaction between fluorine and bromine is reversible and thus a chemical equilibrium is established.

(i) *Explain* the effect that increasing the *pressure* will have on the equilibrium yield.

(ii) *Explain* the effect that increasing the *temperature* will have on the equilibrium yield.

(iii) *Explain* the effect that *adding a catalyst* will have on the rate of reaction.

Your answers to part (b) should include a clear statement of Le Chatelier's principle, and should show a clear understanding of how this principle applies to the situations described.

Question 6

This question relates mainly to Objectives 23, 26 and 28 of Block 8, and carries 21% of the marks for this assignment. It will also help with your achievement of the following general learning outcomes for S103 (see pages 2–3 of this booklet).

Knowledge and understanding skills: outcomes 1, 2 and 4

Cognitive skills: outcomes 1–3

Key skills: outcomes 1–3

Figure 1, on page 22 of this booklet, illustrates four reactions involving carbon compounds. Full structural formulae are shown. The equations for reactions 1 and 4 are incomplete, and the missing product or reactant is indicated by a question mark (?). The equation for reaction 3 is not balanced because we are concerned only with the organic reactant and product.

Complete parts (a) to (d) below, marking your answers on Figure 1. When you are satisfied with your annotations transfer your final answers to the **copy of Figure 1** provided on page 31of this assignment booklet.

(a) (*5 marks*) **Reaction 1**

(i) Identify any functional group(s) in the reactant carbon compound shown, by circling and naming them on Figure 1.

(ii) Complete the equation by drawing the *full structural formula* of the product of this reaction in place of the question mark on Figure 1.

(iii) *State* the type of reaction that has occurred.

(b) (*4 marks*) **Reaction 2**

(i) Identify any functional group(s) in the reactant carbon compound, **y**, and the product carbon compound, **z**, by circling and naming them on Figure 1.

(ii) *State* the type of reaction that has occurred and *explain* how you have arrived at your answer. (*A single sentence*)

(c) (*4 marks*) **Reaction 3**

(i) Identify any functional group(s) in the reactant and product by circling and naming them on Figure 1.

(ii) *State* the type of reaction that has occurred and *explain* how you have arrived at your answer.

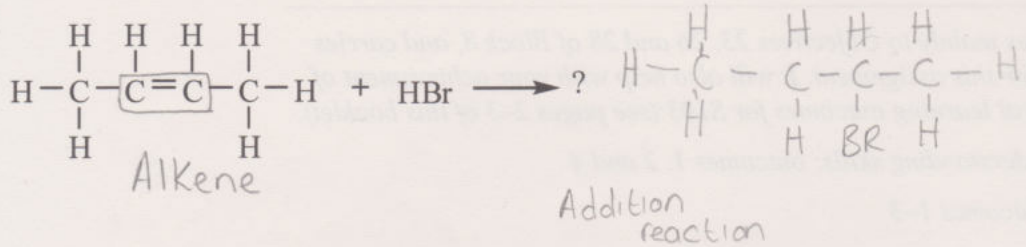
(d) (*8 marks*) **Reaction 4**

(i) Complete the equation by identifying the missing reactant and drawing the *full structural formula* in place of the question mark on Figure 1.

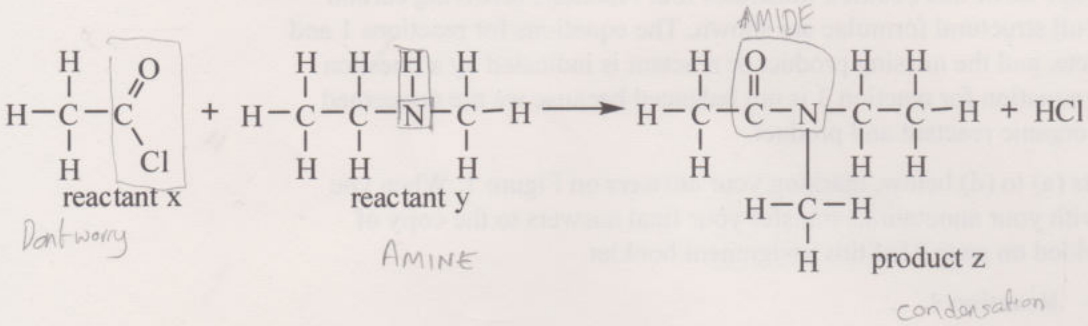
(ii) *State* the type of reaction that has occurred and *outline* the importance of both this reaction and its reverse in biological processes. (*Two or three sentences*)

(iii) *Explain* whether or not the reverse of this reaction could lead to the formation of a polymer. (*Two or three sentences*)

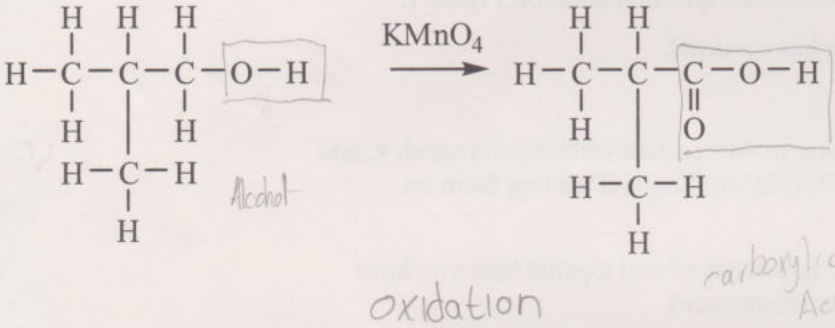
Reaction 1:



Reaction 2:



Reaction 3:



Reaction 4:

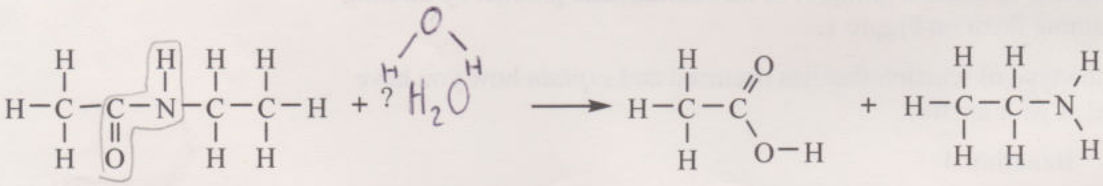


Figure 1 Four reactions involving carbon compounds, for use with TMA 06 Question 6.

Do not forget to send the copy of your completed Figure 1 to your tutor with your TMA.

Question 7

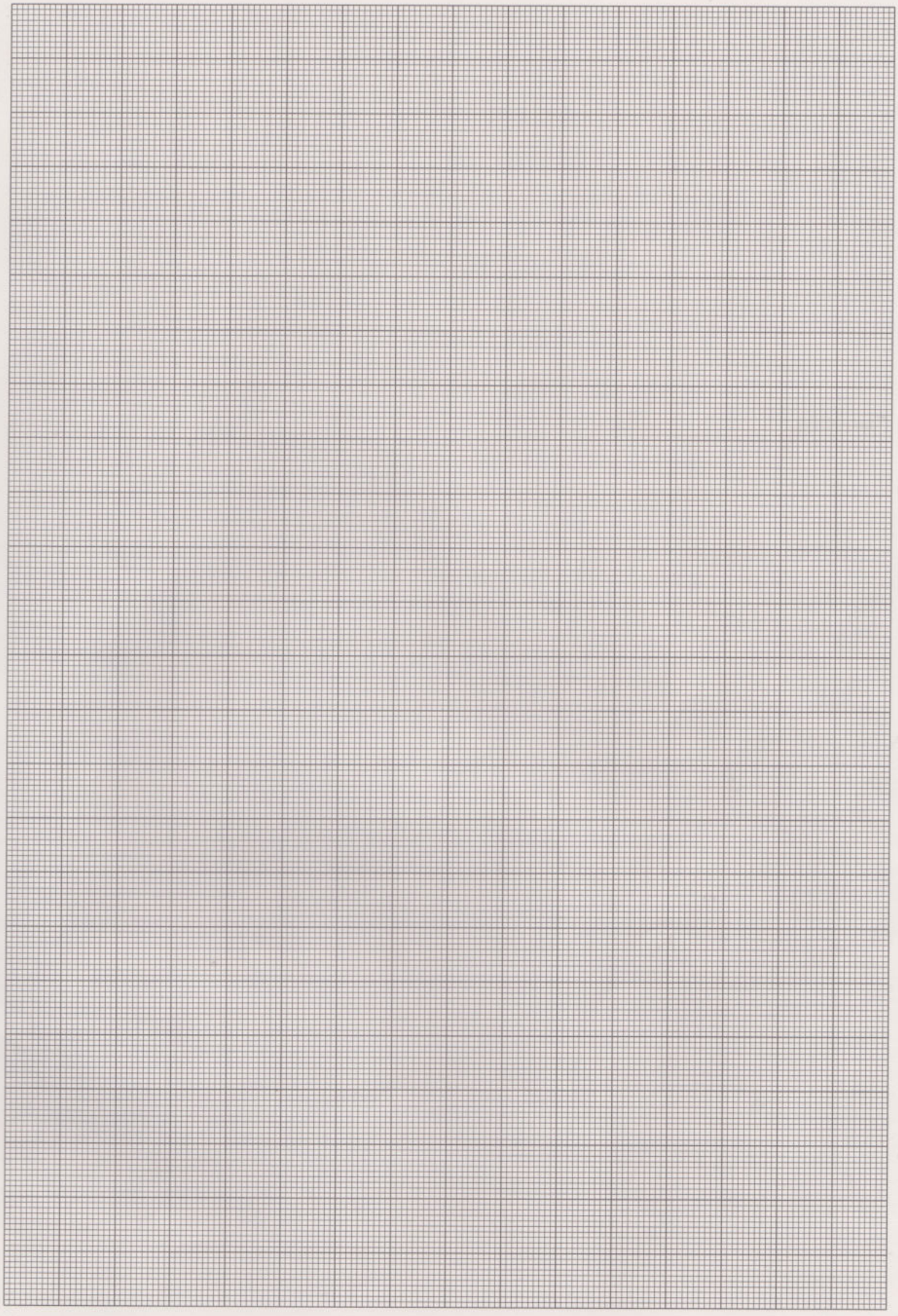
This question refers back to Objective 36 of Block 2, relating to your ability to plan your study time over a four-week study period. At this stage of the course, however, you should have developed the experience to plan your study over a significantly longer period. This question carries 5% of the marks for this assignment.

Now that you have completed TMA 06 you should have decided which one of Blocks 9–11 you intend to focus your study on, and which two of TMAs 07–09 you intend to submit. Because it is important that your tutor knows your intentions, this question concerns your preparation of a personal study plan.

Construct your personal study plan for the remainder of the course using a similar format to that of the S103 Study Calendar. Your calendar should indicate:

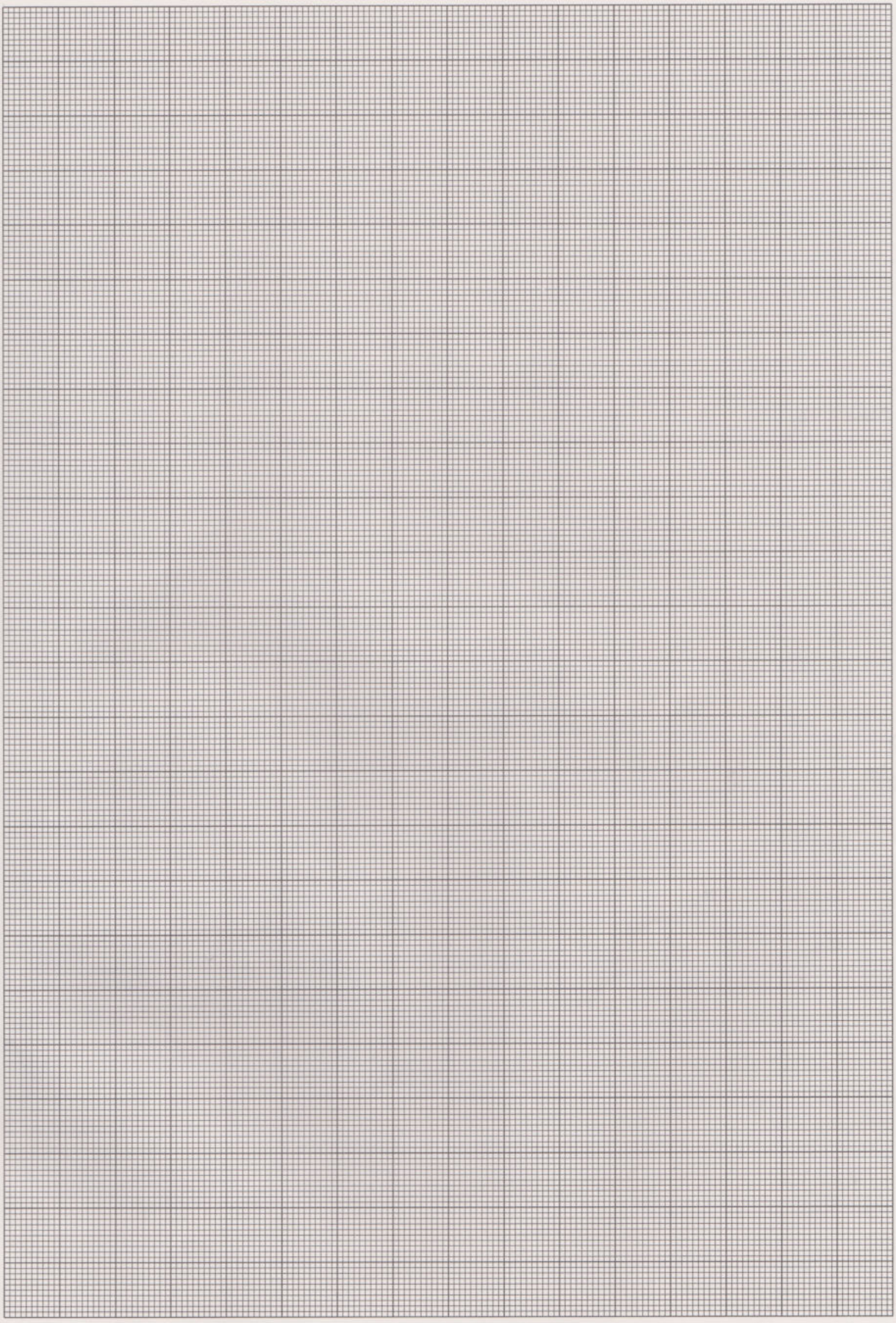
- a week-by-week breakdown of when you intend to study each of your chosen Blocks;
- which of Blocks 9–11 you intend to study;
- any period of time when you will be unable to study, or when you know that your usual study time per week is likely to be significantly reduced because of other commitments;
- the cut-off dates for the two TMAs that you intend to submit and the cut-off date for the end-of-course assessment (ECA).

Note that if you are not intending to submit TMA 07, you should consider setting your own submission 'target dates' for TMA 08 and TMA 09, where these target dates are earlier than the official cut-off dates. This will give you plenty of time to study Block 12 and prepare the ECA.



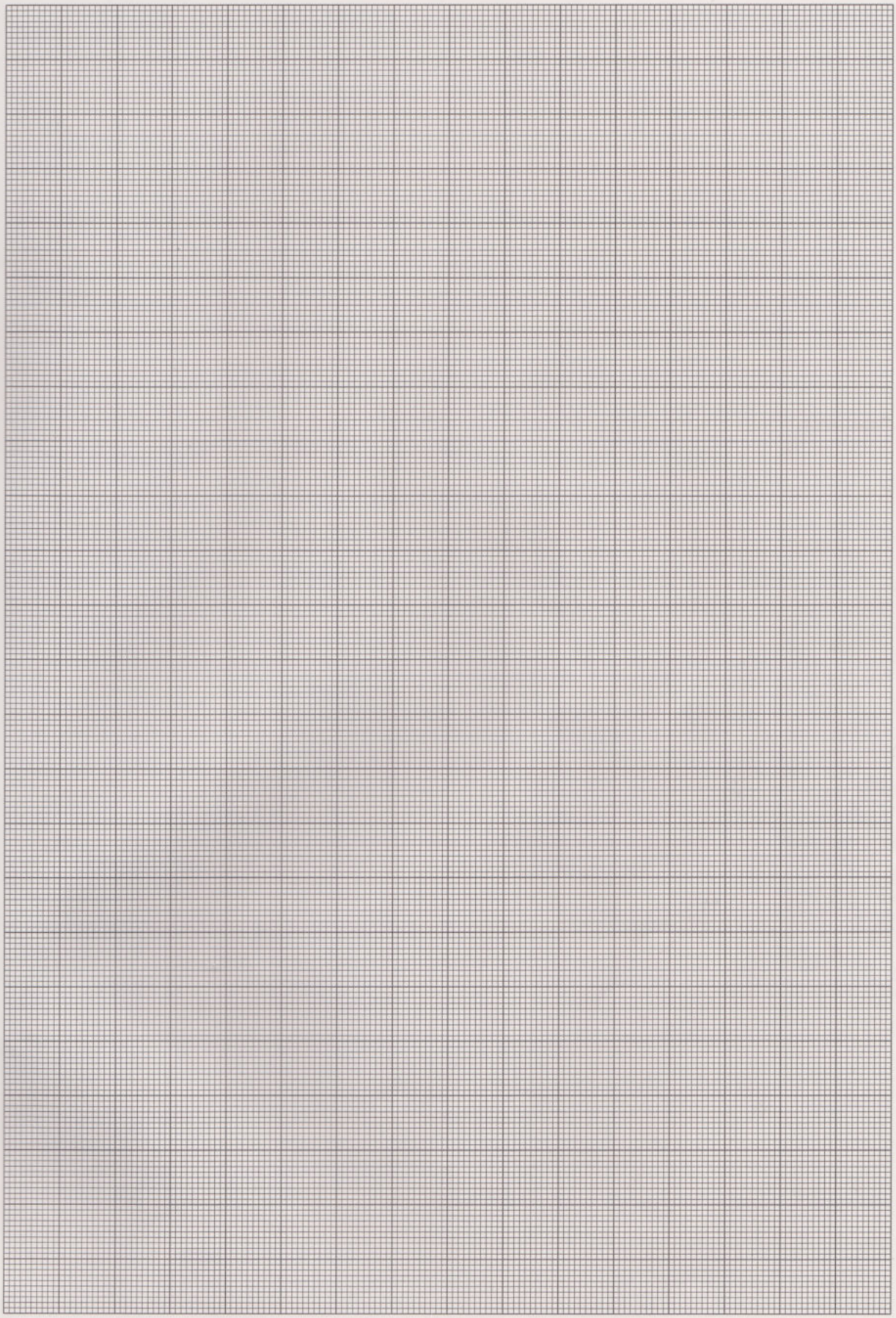
Graph paper for use with TMA 04 Question 1(a)

Personal Identifier								



Graph paper for use with TMA 04 Question 1(b)

Personal Identifier								



Graph paper for use with TMA 04 Question 1(d)

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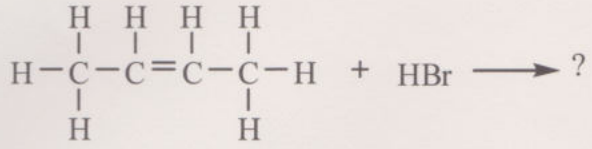
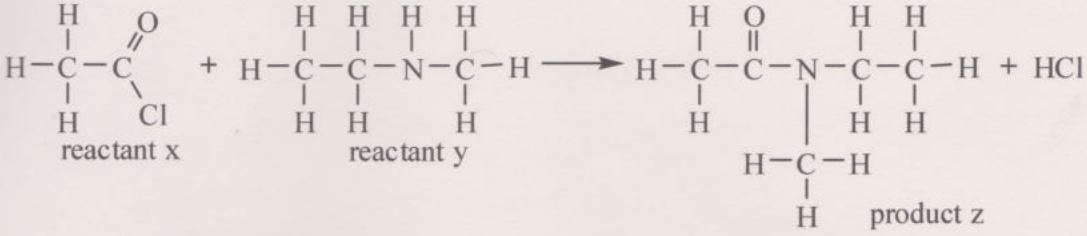
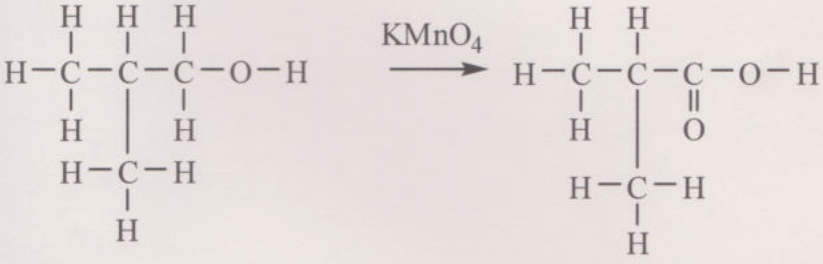
Reaction 1:



Reaction 2:



Reaction 3:



Reaction 4:

Copy of Figure 1 for use in TMA 06 Question 6.

You should cut out this page from the Assessment Booklet and send it with the rest of your TMA to your tutor. Fill in your Personal Identifier in the grid below.

Personal Identifier								